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A methodology and database to quantify the confidence level of methods for gas–liquid two-phase flow pattern prediction

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ABSTRACT

A novel methodology is presented to quantify the confidence level in the prediction of gas–liquid two-phase flow patterns in pipes. An experimental flow pattern data base has been collected, consisting of 12 studies (a total of 9029 data points). The experimental data are compared with the predictions of the unified Barnea (1987) model (any other model/method can be used), and the confidence level in the predictions is quantified. Also, gaps in the data base are identified and future studies required in this are discussed.

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1. Introduction

The term “flow pattern” refers to the spatial distribution of the phases, which occur during gas–liquid two-phase flow in pipes. When gas and liquid flow simultaneously in a pipe, the two phases can distribute themselves in a variety of flow configurations. The flow configurations differ from each other in the interface distribution, resulting in different flow characteristics.

Determination of flow patterns is a fundamental problem in two-phase flow analysis. Indeed all the design variables, namely, phase velocity, pressure drop, liquid holdup, heat and mass transfer coefficients, residence time distribution, and rate of chemical reaction, are all strongly dependent on the existing flow pattern. Thus, knowledge of the existing flow pattern can help the industry carry out a better design of two-phase flow systems. These include accurate prediction of pressure drop and liquid inventory in pipe flow, and effective erosion corrosion planning, utilizing properly chemical additives, such as corrosion inhibitors and demulsifiers. Also, segregated flow patterns are often desired for phase

separation efficiency improvement. Nowadays, a downward inclined inlet section may be installed upstream of the separator, for promoting stratification and pre-separation of the phases. This can be designed utilizing flow pattern prediction to ensure stratified flow at the inlet section. Finally, the transport and deposition of solid particles, e.g., hydrates, paraffins and waxes, is an important flow assurance issue, which is strongly affected by the different flow patterns.

In designing the above applications risky decisions can be made based on the predicted flow pattern, which can result in severe economical losses. Thus, it is very important to determine the confidence level in the prediction of the existing flow pattern. However, no past studies have attempted to address the confidence level in such predictions.

Fig. 1 presents the different transition boundaries occurring in gas–liquid flow, as well as the different existing flow patterns. The physical mechanisms and respective models of the different transition boundaries can be found in Shoham (2006). Following is a summary of the commonly accepted flow patterns, for the entire range of inclination angles.

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